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APEX PROFILER USER MANUAL

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Firmware Revision APF9I F/W **12/02/10**

Features:

APF9I Controller

Park and Profile

Deep Profile First (DPF)

Air pump energy consumption limit

Time of Day profile control

Non-modal behavior

Depth Table 30

Ice Detection and Evasion

Rafos (optional)



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I. Alkaline Battery Warning

The profiler contains batteries comprised of alkaline manganese dioxide "D" cells.

There is a small but finite possibility that batteries of alkaline cells will release a combustible gas mixture. This gas release generally is not evident when batteries are exposed to the atmosphere, as the gases are dispersed and diluted to a safe level. When the batteries are confined in a sealed instrument mechanism, the gases can accumulate and an explosion is possible.

Teledyne Webb Research has added a catalyst inside of these instruments to recombine hydrogen and oxygen into H₂O, and the instrument has been designed to relieve excessive internal pressure buildup by having the upper end cap release.

Teledyne Webb Research knows of no way to completely eliminate this hazard. The user is warned, and must accept and deal with this risk in order to use this instrument safely as so provided. Personnel with knowledge and training to deal with this risk should seal or operate the instrument.

Teledyne Webb Research disclaims liability for any consequences of combustion or explosion.

Acknowledgements

Teledyne Webb Research would like to acknowledge the contribution made by the University of Washington, School of Oceanography, towards the technical content of this User Manual.

II. APF9 Operations Warning for APF8 Operators

This APEX manual describes floats using a new controller design. The new design is designated APF9. The prior design, which is still in production and widely used, is designated APF8.

The operator interface and behavior of the APF9 are similar to, **but not identical to**, the operator interface and behavior of the APF8. If you are an experienced APF8 user, please observe appropriate cautions and **do not assume an expected behavior**. Several important differences are listed below. These points should also be helpful to those without an APF8 background.

- The serial baud rate for communications is 9600, with 8 data bits, no parity, and 1 stop bit. (The APF8 baud rate is 1200.)
- APF9 floats using this *non-modal* version of firmware are shipped in Pressure Activation mode. The Reset Tool can then be used to toggle between Pressure Activation mode, and starting a new mission.
- If the APF9 is performing some task (e.g., self tests), it is not listening and cannot be placed in Command Mode with either the Reset Tool or a keystroke at the terminal.
 - There is one exception. If the piston is moving, the Reset Tool (but not a keystroke) can be used to terminate the move. The APF9 will transition to its next state or task. Typically this will be either Command Mode or Sleep, so try a keystroke or a second application of the Reset Tool after the piston stops to confirm or trigger the transition to Command Mode.
- If the APF9 is not responding, it is probably busy with some task. Be patient and occasionally try to get the attention of the float with either the Reset Tool or a keystroke.
- The logging verbosity of the APF9 can be adjusted by the operator. The level, Parameter D, Logging verbosity [0-5], adjusts the amount of information provided in diagnostic messages from the float, with 5 being the highest level. A logging verbosity of 2 is the default. **Only level 2 has been thoroughly tested in simulation, so this parameter should be set to 2 for all deployments.** Higher levels are suitable during testing as an aid to float assessment.

III. APF9I Operations Warning for APF9A Operators

The "look and feel" of the APF9I operator interface is quite similar to the APF9A operator interface. However, there are some differences of which you should be aware:

- The APF9I uses minutes, not hours, for mission parameter timing intervals
- Air bladder inflation is the only visible evidence that the float passed the self-test and is ready for deployment. The APF9I does not make six test transmissions that can be detected with an external RF receiver.
- The maximum air bladder pressure is (and should be) higher in the APF9I (6.2 inHg) than in the APF9A (5.3 inHg). This is to assure robust connectivity for the Iridium antenna.

IV. Maximum Operating Pressure

APEX profilers have a maximum operating pressure of 2000 dbar (2900 psi). However, for shallower applications, thinner walled pressure cylinders can be used. These cylinders have a reduced pressure rating, but less mass, which allows them to carry a larger battery payload.

Three cylinder pressure ratings are available:

- 2000 dbar maximum pressure rating
- 1500 dbar battery payload typically 14% greater than with 2000 dbar cylinder
- 1200 dbar battery payload typically 28% greater than with 2000 dbar cylinder

For example, if an APEX profiler is specified by the customer for 1400 dbar maximum (profile) depth, then the 1500 dbar cylinder would normally be used.

CAUTION:

If you will be:

- Exposing floats to significant hydrostatic pressure during ballasting or testing
- Re-ballasting and re-programming floats for a depth greater than the original specification

Please contact TeledyneWebb Research to confirm the pressure rating of specific floats. Do not exceed the rated pressure, or the hull may collapse.

V. Evaluating the Float and Starting the Mission

APF9I profilers use either *modal* or *non-modal* controllers. Since the type of controller determines the behavior of the Reset Tool, it is extremely important to determine which type of controller is loaded on the profiler. The controller described in this manual is *non-modal*, meaning that the float will be shipped in Pressure Activation mode, and the Reset Tool can be used to toggle the float between Pressure Activation mode, and starting a new mission. This contrasts with *modal* floats, in which the Reset Tool is always used to start a mission (and not to put the float in Pressure Activation mode).

The motivation for using non-modal controllers is to reduce the risk of launching floats that do not start missions. For non-modal controllers, the float will always run a mission when launched: either because of Pressure Activation, or because the float is already running a mission. This is not true for 'modal' controllers, which could be launched without either Pressure Activation, or without a mission running. From this point on, this manual describes only non-modal behavior.

If physically connected to the float (using a communication cable between a PC and the float, as described in the section "Connecting a Terminal" at the end of this manual) it is also possible to put the float into an 'inactive' state. Once connected, the 'i f' (freeze command) immediately makes the float hibernate, powering it down and placing it in an 'inactive' state. The 'i * i' command also places the float in an 'inactive' state, although the float will remain awake and communicating. Entering a 'q' command (or not communicating for ... minutes) will then place the float into Pressure Activation mode. Either way, the easiest way to determine the state of the connected float is via the 'i * s' command, which gives the state as well as any mission time.

Another non-modal float behavior is that if any corrupted or ill-formed data is received from the CTD sensor, then the mission is automatically started (if not already running). This ensures that the user will be notified of the problem. However, this presents another risk when leaving a float in the lab, connected to a power-source, but with no pressure sensor or piston-position sensor attached. If the float wakes (on the two hourly interval) and detects no CTD data, a mission is automatically started. This extends the piston, but with no piston-position sensor attached there is a risk of extending the piston too far.

The following sections, "Manual Deployment with the Reset Tool" and "Pressure Activation Deployment", provide operational summaries for the two possible deployment scenarios. Both sections refer to self tests conducted by the float and the float function checks performed by the operator.

Teledyne Webb Research strongly recommends testing all APEX Profilers on receipt by the customer and before deployment to ensure no damage has occurred during shipping.

A. Manual Deployment with the Reset Tool

Since the Reset Tool toggles between Pressure Activation mode and starting a new mission, start a new mission by first ensuring that the float is in Pressure Activation mode, and then hold the Reset Tool over the marked location on the pressure case for approximately 3 seconds. Remove the Reset Tool only after you hear the air pump activate.

The float will run a brief self test and place itself in a state of maximum buoyancy. This is the Mission Activation phase. During this time the operator should verify proper function of the float (see "Mission Activation and Operator Float Function Check"). The float will telemeter its GPS location and the mission parameters during the Mission Prelude phase. Six hours is typical; the duration of the Mission Prelude can be set by the operator. The piston will be fully extended and the air bladder will be fully inflated during the Mission Activation phase. At the conclusion of the Mission Prelude the float will retract the piston, deflate the air bladder, and begin its pre-programmed mission.

Manual Deployment Summary:

- Ensure that the float is in Pressure Activation mode before toggling
- Toggle to start a new mission by holding the Reset Tool over the RESET label
- Mission Activation
 - Air pump runs for 1 second
 - Self tests conducted
 - The self tests can be monitored if a communication cable is connected, see "Connecting a Terminal"
 - If the float passes the self tests:
 - Piston is fully extended
 - Air pump is cycled on and off until the air bladder is fully inflated
 - Air bladder inflation is the only easily verified indication that the float has pass the self tests and is ready to deploy
- Mission Prelude
 - Float telemeters GPS location and mission parameters
 - The telemetry interval is set by the operator, Parameter Mhr
 - Mission Prelude duration is typically 6 hours

The float can be deployed after the Mission Activation phase and confirmation of proper float function have been successfully completed. We advise waiting until the air bladder is fully inflated before deploying the float.

If the float fails the self tests the piston will not extend and the air bladder will not inflate. The float should not be deployed.

B. Pressure Activation Deployment

Non-modal floats are shipped in Pressure Activation mode, so no operator action is required to set this mode. In this mode, the float checks the pressure every two hours. If the measured pressure is greater than 25dbar the float starts its mission. Otherwise, the float moves the piston to the position indicated by mission parameter 'P-Activation piston position' (if not already there) and goes to sleep for another two hours.

Note that this behavior does present some risk. For example, if 'P-Activation piston position' was set to a value that would make the float bouyant at the surface (e.g. around 100) then a float launched in this mode would never sink, and would never activate (start) its mission. For this reason, 'P-Activation piston position' is typically set to around 16. At this setting the float would sink below 25dbar, and consequently start its mission.

Pressure Activation Deployment Summary:

- Deploy the float (no toggling is required since the float is delivered in Pressure Activation mode)
- Pressure Activation
 - Pressure is measured every 2 hours
 - Pressure in excess of 25 dbar triggers
 - Full piston extension
 - Transition to Mission Prelude
- Mission Prelude
 - During ascent the float looks for a satellite at each telemetry retry interval (Parameter Mhr)
 - Detection of a satellite (surface) triggers
 - Full air bladder inflation
 - Float telemeters GPS location and mission parameters
 - The telemetry interval is set by the operator, Parameter Mhr
 - Mission Prelude duration is typically 6 hours
 - **In this particular version of the APF9I firmware, the Mission Prelude will terminate after the first successful telemetry cycle (or it will time out after 9 hours)**

C. Mission Activation and Operator Float Function Check

- 1) Secure the float in a horizontal position using the foam cradles from the shipping crate.
- 2) The minimum internal temperature of the float is -2.0°C . If necessary, allow the float to warm up indoors before proceeding.
- 3) Remove the plastic bag and three (3) plugs from the CTD sensor as shown in the two images below.



- 4) Carefully remove the black rubber plug from the bottom center of the yellow cowling as shown in the image below. This will allow you to verify air bladder inflation in the steps below. **Use only your fingers to remove the plug. Tools may puncture or otherwise harm the bladder. Be sure to replace the plug before deployment!**

Note: It can be difficult to replace the plug when the air bladder is fully inflated. We suggest that you reinsert the plug before the bladder is fully inflated. The plug prevents the entry of silt into the cowling in the event the float contacts the sea floor.



- 5) Start a Manual or Pressure Activated Deployment. This will trigger the Mission Activation self tests. Where applicable, the description below indicates where the two versions of the self tests differ.

Verify by ear that the air pump is activated for approximately 1 second.

DO NOT DEPLOY THE FLOAT IF IT DOES NOT BEHAVE AS DESCRIBED BELOW. FLOATS THAT DO NOT PASS THE SELF TESTS SHOULD NOT BE DEPLOYED. CONTACT TELEDYNE WEBB RESEARCH FOR ASSISTANCE.

- 6) The float will conduct self tests for approximately 15 seconds. Progress and diagnostic messages will be displayed if a terminal is connected to the float (see "Connecting a Terminal" for additional information).
- 7) If the float passes the self tests:

Manual Deployment: If not already fully extended, the float will fully extend the piston. This process may require up to 25 minutes. The oil bladder will expand during this time. The float will also fully inflate the air bladder.

Pressure Activated Deployment: If not already fully retracted, the float will fully retract the piston. This process may require up to 25 minutes. The oil bladder will deflate during this time. The float will also deflate the air bladder.

The volume of oil in the bladder is difficult to detect by hand. You may be able to hear the pump by placing your ear against the hull. Air bladder inflation can be easily verified as described in Step 4.

- 8) Manual Deployment: Once the piston is fully extended the float enters the Mission Prelude phase. During this phase it will telemeter its GPS location and the mission parameters. Check for air bladder inflation by sticking your finger (**not a tool!**) through the hole in the bottom of the yellow cowling as described in Step 4 above. **Don't forget to replace the plug before deploying the float.**

The duration of the Mission Prelude is set by the operator. 6 hours is typical. At the end of the Mission Prelude the float will deflate the air bladder, retract the piston, and begin the first descent of the programmed mission.

Pressure Activated Deployment: Once the piston is fully retracted the float will enter the Pressure Activation phase. During this phase it will check the pressure every two hours, hibernating in between. The float will not enter the Mission Prelude phase until it detects a pressure in excess of 25 dbar. There will be no telemetry nor inflation of the air bladder until the Mission Prelude phase begins and the surface is detected.

When the trigger pressure is detected the float will extend the piston and begin the Mission Prelude. During this phase it will attempt to locate a satellite while ascending. Once a satellite is detected (surface detection), the float will telemeter its GPS location and the mission parameters for the balance of the Mission Prelude. The duration of the Mission Prelude is set by the operator. 6 hours is typical. At the end of the Mission Prelude the float will deflate the air bladder, retract the piston, and begin the first descent of the programmed mission.

In this particular version of the APF9I firmware, the Mission Prelude will terminate after the first successful telemetry cycle (or it will time out after 9 hours)

- 9) The float is ready to deploy.

C. Notes and Caveats

Self Tests: During the self tests the float checks:

- The internal vacuum
- Communication with the CTD
- The internal alarm timer settings

If any of the self tests fail the float will abort the mission. The clearest indication to the operator that this has occurred is the failure of the float to make the initial 6 ARGOS transmissions at 6 second intervals.

If you do not detect these Mission Activation transmissions with the Cat's Meow, DO NOT DEPLOY THE FLOAT!

Manual Deployment: In the case of a Manual deployment, if the float is not deployed before the completion of the Mission Prelude phase,

RESET the float again and wait for it to complete the Mission Activation phase and begin the Mission Prelude before you deploy it.

Pressure Activated Deployment: In the case of a Pressure Activated Deployment, the operator is necessarily absent when the float begins the Mission Prelude. This means the operator does not have the opportunity to check the air bladder for leaks that a Manual Deployment offers.

For this reason we strongly recommend that you manually inflate and check the bladder before starting a Pressure Activated Deployment.

Telemetry Testing: During the Mission Prelude the float will telemeter data to the host server.

The float must have a view of the sky to telemeter successfully. Starting a manual deployment, allowing the float to complete several telemetry cycles, and confirming the reception of the telemetered files at the host server and back at the float (leave the communications link connected) constitutes a valid and easily conducted test of the full communications system.

VI. Deploying the Float

- 1) Pass a rope through the hole in the plastic damper plate, which is shown in the image at right. The rope should fit easily through the hole and be capable of supporting 50 kg (100 lb).
- 2) Holding **both** ends of the rope bight, carefully lower the float into water. The damper plate is amply strong enough to support the weight of the float. However, do not let rope slide rapidly through the hole as this may cut the plastic disk and release the float prematurely.
- 3) Take care not to damage the CTD or the Iridium antenna against the side of the ship while lowering the float.
- 4) **Do not leave the rope with the instrument.** Once the float is in the water, let go of the lower end of the rope and pull on the top end slowly and carefully until the rope clears the hole and the float is released.



It may take several minutes for the cowling protecting the bladder to fully flood with water and the float may drift at an angle or even rest on its side during this period. This is normal behavior and not a cause for concern.

- 5) Manual Deployment: The float will remain on surface for the duration of the Mission Prelude.

Pressure Activated Deployment: The float will sink immediately. It will return to the surface within 3 hours and begin the Mission Prelude after detecting a pressure in excess of 1500 dbar.

VII. Park and Profile

The APF9I float can be set to profile from a maximum depth (Profile Depth) after a programmable number (N) of profiles from a shallower depth (Park Depth). Special cases are conducting all profiles from either the Profile Depth or the Park Depth. The latter is an important special case that can be selected by setting $N = 254$. This will cause all profiles to start at the Park Depth; the programmed Profile Depth is ignored. Between profiles the float drifts at the Park Depth.

Terminology:

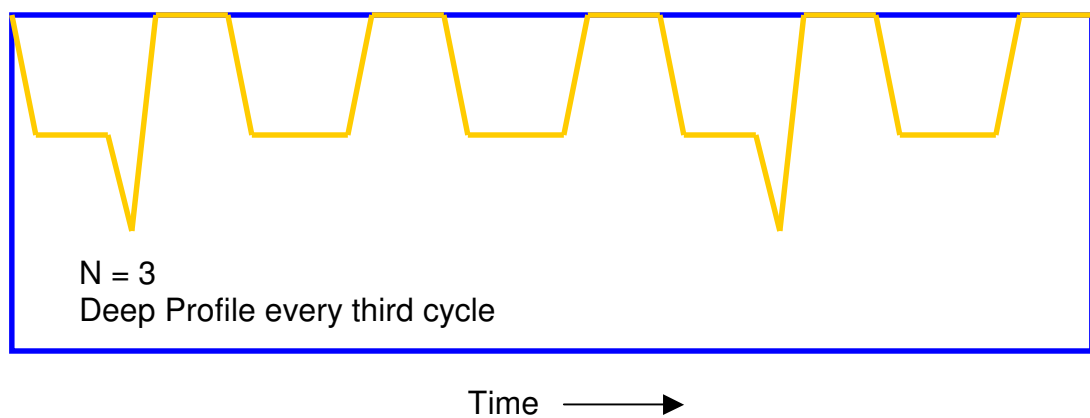
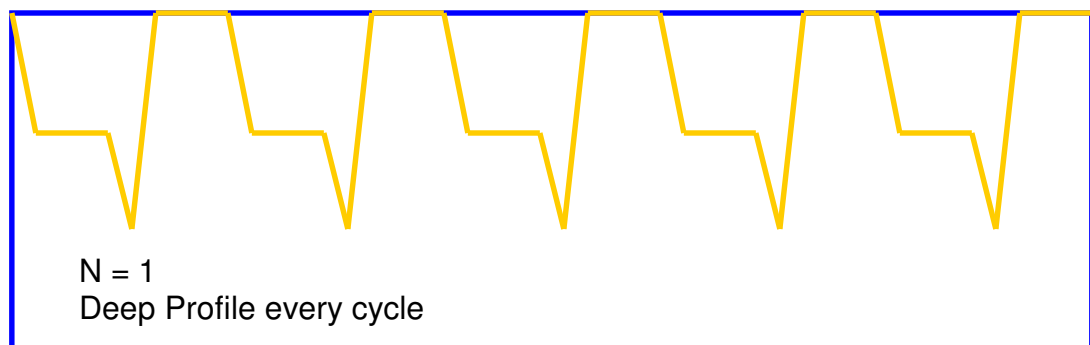
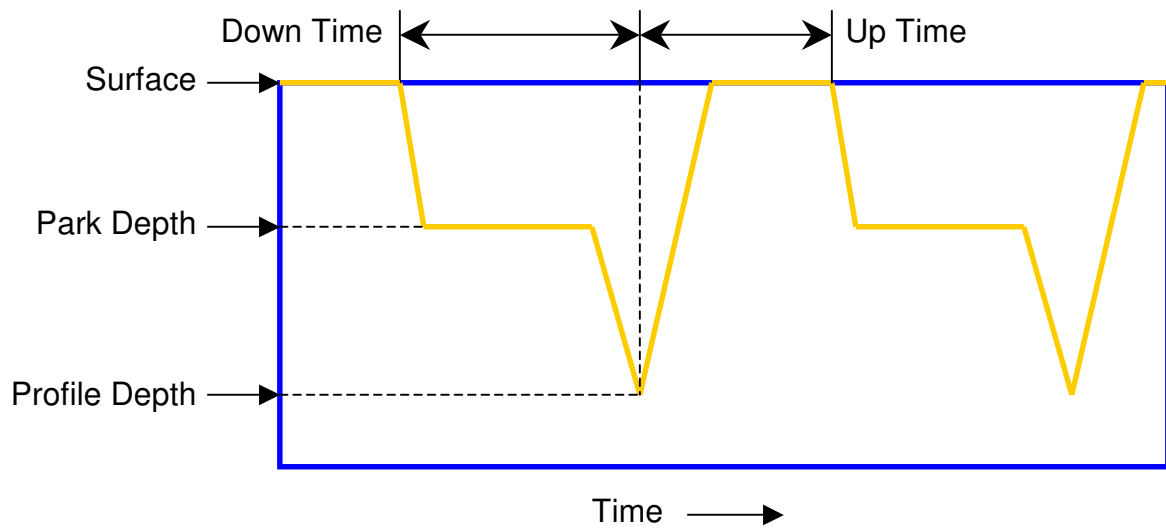
- Park Depth Intermediate depth at which the float drifts between profiles and from which the float profiles in cycles not evenly divisible by N.
- Profile Depth Maximum depth to which the float descends from the Park Depth every Nth cycle and from which each Nth profile is conducted.
- Down Time Programmed time-limit for descending from the surface and drifting at the Park Depth. Down Time is commonly set to 10 days or to 10 days less the Up Time.
- Up Time Programmed time-limit for ascending from the Park or the Profile Depth and drifting at the surface while transmitting the data acquired during the profile. Up Time is typically set between 12 hours and 20 hours, increasing with the amount of data to be transmitted per profile. The latitude of the deployment also matters; ARGOS satellites are in polar orbits, so the number of satellite passes per day increases with latitude.
- Ascent Rate The ascent rate of the float is maintained at or above 8 cm/s. The float extends the piston by a user specified amount to add buoyancy when the ascent rate falls below this threshold.

A. Profile Ascent Timing

Profiles from the Park Depth begin when the operator programmed Down Time expires. The float extends the piston by an operator programmed initial amount and begins the ascent.

When a profile is to begin from the Profile Depth, the float will retract the piston and descend from the Park Depth an operator programmed interval before the expiration of the Down Time. This interval, Parameter Mtj, Deep-profile descent time in hours, provides the additional time needed to descend to and profile from the Profile Depth without losing significant surface time, the period when data from the profile are transmitted.

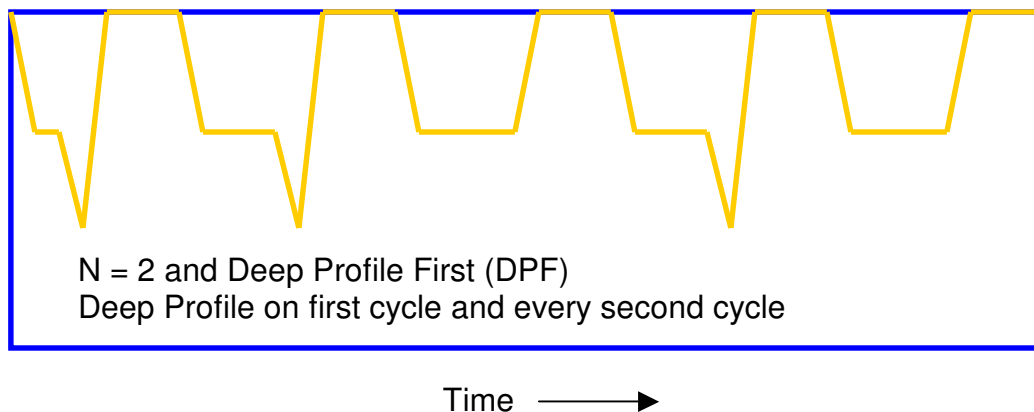
B. Profile and Profile Cycle Schematics



VIII. Deep Profile First (DPF)

Independent of the Park and Profile cycle length, the first profile is always a Deep Profile that begins at the Profile Depth. This means the float returns a CTD profile relatively soon, typically less than a day, after the float is deployed. This feature supports comparison of the initial float profile with a conventional CTD cast from the ship.

The first descent begins at the end of the Mission Prelude. A schematic representation of DPF with a Park and Profile parameter $N = 2$ is shown below.



Note: For maximum battery life in ARGO applications, Teledyne Webb Research recommends use of $PD > one$, with park depth ≤ 1500 db.

IX. Air Pump Limits

At the beginning of each telemetry cycle the float verifies that the air bladder is fully inflated. If the pressure does not exceed the threshold, Parameter Mfb, the float will further inflate the bladder, cycling the air pump on for 1 second and off for 1 second until the pressure exceeds the threshold. The use of the air pump is limited to 2000 Volt-seconds during each profile cycle to prevent excessive battery drain in the event of a problem in the air system that prevents full inflation.

The maximum air bladder pressure is higher (6.2 inHg) in the APF9I than in ARGOS equipped floats (5.3 inHg). The higher pressure allows Iridium floats to ride higher at the surface to assure robust connectivity for the Iridium antenna.

X. Setting the Real-Time Clock

The APF9I is equipped with a real-time clock (RTC). The RTC can be set by the operator to any desired reference time. However, the float will automatically update the RTC each time a GPS fix is obtained if the RTC and the GPS satellite disagree by more than 30 seconds.

As a consequence, APF9I floats will end up running on GMT eventually, so the operator should only set the RTC to GMT to avoid confusion and scheduling problems. This is particularly important if the TOD feature is to be used.

To view or set the RTC, enter the Main Menu (see "[Connecting a Terminal](#)" and "[APF9I Command Summary](#)") and use the 't' command as shown in the examples below:

Viewing the RTC:

```
> t                               ← entered by operator followed by [ENTER]
Real time clock: Fri Sep 25 04:47:05 1970
```

Setting the RTC:

```
> t 07/24/2007:17:11:00           ← entered by operator as mm/dd/yyyy:hh:mm:ss
(Sep 25 1970 04:47:45, 393506 sec) ParseTime()           The time
                        string represents the date Tue Jul 24 17:11:00 2007
Real time clock: Tue Jul 24 17:11:01 2007
```

The date and time must be entered in the format shown in the example above. The RTC will revert to 1970 if the batteries providing power to the APF9I are disconnected. In this case the operator should reset the RTC after restoring power to the float.

XI. Time of Day (TOD)

APF9I floats have the option of scheduling profiles so that the float surfaces at a particular time of day (TOD). The APF9I real-time clock is used to dynamically set the end of the Down Time to some user specified number of minutes after midnight. The operator must take into account any difference between the time zone of the deployment and GMT when setting this parameter. **Remember that the RTC of the float will be set to GMT whenever the float obtains a GPS fix, so you cannot control the time zone of the RTC.** This is described in more detail below.

The TOD feature is applied by the float as follows:

- At the start of a descent (end of Up Time), the APF9I computes a Down Time expiration based on the Down Time programmed by the operator.
- If the TOD feature is disabled, the Down Time will expire at that calculated time of the RTC.
 - For example, if the Down Time is set to 120 hours (10 days) and the Up Time ends at 14:00 on July 10, 2007, the next Down Time will expire at 14:00 on July 20, 2007.
- If the TOD feature is enabled, the float extends the Down Time expiration to the next occurrence of "TOD minutes after midnight" on the RTC.
 - For example, if the initial calculation placed the Down Time expiration at 14:00 on July 20, 2007 (as above), but the TOD was enabled and set to 1200 minutes (20 hours after midnight), the Down Time would be extended from 14:00 and set to expire at the next occurrence of 20:00, which is 20:00 on July 20, 2007.

Active ballasting and all other Down Time behaviors continue until the Down Time expires. This will be until 14:00 in the first example and until 20:00 in the second example.

Controlling TOD

The TOD feature must be manually enabled by the operator. This is done by entering the Mission Programming Agent ('m' from Main Menu, see "[Connecting a Terminal](#)" and "[APF9I Command Summary](#)") and setting Parameter Mtc to an allowed value in minutes. Setting Parameter Mtc to no value will disable the TOD feature.

Enabling TOD

```
> t c 360                                     ← entered by operator followed by [ENTER]
The down-time will expire at 360 Minutes after midnight.
```

Disabling TOD

```
> t c                                         ← entered by operator followed by [ENTER]
The time-of-day feature has been disabled.
```

Shifting the Time Zone

Because the RTC is necessarily set to GMT, the operator must account for the time zone difference between the float and GMT in setting TOD. For example, assume:

- The float will be deployed in the eastern Pacific (10 hours behind GMT, 12:00 GMT is 02:00 in the eastern Pacific)
- The operator wishes to use the TOD feature to set Down Time expiration to 20:00 in the local time zone

20:00 in the local time zone is 06:00 GMT (10 hours later). Therefore, set TOD to 360 minutes (6 hours). Down Time will expire at 06:00 GMT, which is 20:00 in the local time zone.

Selecting a TOD Value

To select a TOD value, you must first decide what time you wish the float to surface. Then calculate the approximate duration of the profile, which begins with the expiration of the Down Time. The calculation is based on the programmed depth from which the float will ascend and assumes an ascent speed of 0.08 dbar per second.

For example, a 1200 dbar profile requires approximately 4 hours.¹ If you wish to have the float reach the surface at approximately 02:00, set TOD so that the Down Time will expire 4 hours earlier. Four hours earlier is 22:00, which is 1320 minutes after midnight. Therefore set TOD to 1320 minutes.

If profiles are to be conducted from both the Park Depth and the Profile Depth and the operator wishes the float to reach the surface at a consistent time, the Deep-profile descent time, Parameter Mtj, must be set to a reasonable value for the descent from the Park Depth to the Profile Depth. See "[Profile Ascent Timing](#)" for additional information.

¹ $(1200 \text{ dbar} / 0.08 \text{ dbar/sec}) / 3600 \text{ sec/hr} = 4.16 \text{ hours}$

XII. Ice Detection and Evasion

This float has an ice detection and evasion feature to enhance float survivability in regions prone to ice cover. When hydrographic features associated with surface ice are detected, the float will descend to avoid damage. For Apf9 floats with iridium, there are three possible detection features: ice cover, ice cap and ice break up.

- Ice cover detection attempts to detect hydrographic features associated with surface ice before reaching the surface.
- In the event that ice cover was not detected, ice cap detection will verify that the float reaches open water and that it is not under free-floating ice blocks.
- If no ice cover is detected, an additional check is implemented to detect leads and periods when the ice is breaking up.

Ice detection and evasion is controlled seasonally on a monthly basis. The user can specify which months to enable ice detection based upon winter conditions for the deployment location.

If ice is detected, ice evasion is initiated. The float will abort the profile and descend, remaining at the park piston position for the duration of the current profile period. For Inidium, the data for the aborted profile is available and will be transmitted in the next successful telemetry cycle.

A. Ice Cover Detection

Ice cover detection is based on temperature measurements starting at 50 decibars. The temperature samples are collected every 2.5 decibars. The sorted median value of the samples is computed at each sample point to characterize the mixed layer temperature hydrography. If at any pressure less than 20 decibars the median of the temperature measurements is less than a user-specified critical temperature, the surface is assumed to be ice covered and ice evasion occurs.

B. Ice Cap Detection

The following conditions together indicate an ice cap is detected and will initiate ice evasion.

- There is no Iridium communication indicating the float does not have a sky view and that sufficient time is given for the opportunity to connect to the satellites and register with the Iridium service.
- Pressure is less than 20 decibars ensuring the float is near the surface.
- Temperature is less than the user-specified critical temperature to determine if the float is within the cold water halo underneath the ice.

C. Ice Break Up Detection

The criterion for determining ice break up is based on the previous 8 profiles' ice evasion history as determined by ice cover and ice cap detection. Ice break up is not recorded as part of the definitive ice detection and evasion history. Assume possibility of break up if either of the following occurs:

- Ice was detected on the previous profile.
- Ice was detected on the oldest 5 profiles plus any of the most recent 3 profiles.

D. Ice Detection Mission Parameters

It is important to understand the intended hydrography. If the critical temperature is set too high, the feature will always evade. If the critical temperature is too low, evasion may not occur during actual ice conditions. The seasonal aspect of this feature can help ensure floats will always profile during desired months.

The default values for the winter months and critical temperature used in ice detection missions (as shown in the mission status list) are:

-1.80 Ice Detection: Mixed-Layer Tcritical (C) Mit
0xTBD Ice Detection: Winter months [DNOSAJJMAMFJ] Mib

The temperature default is based on the value used in other float applications.

The winter months designate which months to enable ice detection processing. Note that if ice detection processing is enabled for a winter month and no ice is detected, the float will still surface and transmit as usual. It is only when ice detection is enabled and ice is detected that the mission is aborted. With knowing the specific region, the safest approach for defaults is to enable ice detection processing for all months except one summer month to ensure surfacing for at least that one month. The bit mask is input as a 3 digit hexadecimal value with each bit representing a month in the order designated. The southern and northern hemisphere defaults are shown below.

DSNOSAJJMAMFJ	Mib	Region
11111111101	FFD	Southern Hemisphere (all months except February)
11110111111	F7F	Northern Hemisphere (all months except August)

These settings should be carefully reviewed for the target hydrography. The values can be modified to better suit application needs if required. For example, if the region is known to be ice-free for 6 months, we can close the winter window to ensure transmission for those summer months.

E. Ice Evasion Telemetry

Telemetry data for an aborted profile is saved and will be transmitted in the next successful telemetry cycle. The ice median temperature and number of samples is provided, as well as an Ice Evasion Record which indicates the ice cover and ice cap detection status for the last 8 profiles. Note that ice break up does not affect this record, but is indicated in the telemetry status word.

F. Special Mission Prelude Note for under-ice operation

Although the mission prelude for these floats are not disabled, there is a capability to bypass mission prelude and immediately sink if the float is to be deployed in ice conditions that may pose a threat to the float.

XIII. Iridium Data

A. Iridium Service and Costs

Each float operator must obtain an Iridium SIM card (Subscriber Identity Module) for each APF9I float. SIM cards are obtained from an Iridium provider who you will need to locate and choose. Iridium charges can be a significant expense and it is worth shopping for a good rate. There are a number of providers and the list is not restricted because the connection is coming from a float in the ocean.

Teledyne Webb Research uses STRATOS:

- <http://www.stratosglobal.com/StratosGlobal.cfm>
- +1-709-748-4233 (Sales Support Worldwide)
- +1-709-748-4280 (Billing Worldwide)

The University of Washington, a customer with a large and growing fleet of APEX floats, uses NAL Research:

- <http://www.nalresearch.com/Airtime.html>
- +1-703-393-1136 x200

Some Iridium providers are "data only". This is appropriate for a float and is the type of service for which you should ask. Like the service, the SIM card should also be "data only".

You will need to send the SIM card and the unlocking PIN to Teledyne Webb Research for us to be able to build and test the float. If you do not change the PIN from the factory default value you will not need to provide the PIN. Please keep a record of the SIM card's serial number (ICCID) and phone number (MSISDN). Both numbers are essential and must stay together as a pair. The firmware includes a command, Parameter Hs, to query and display the ICCID and MSISDN of the SIM card. Similarly, please keep a record of the float's Iridium modem (LBT) serial number (IMEI). Parameter Hi will query and display the IMEI of the LBT.

Billing for Iridium service is monthly. Teledyne Webb Research will give you notice 30 days prior to shipment so that you can activate your SIM card. The card must be activated for Teledyne Webb Research to test the float. The monthly cost for a SIM card is typically \$30.00 (USD). Calls from the float to the host server are charged by the minute (or fraction thereof) at \$1.50/minute. Average data transfer rates are in the range 6 Kbytes to 10 Kbytes per minute. Anticipate 20 Kbytes to 50 Kbytes of data for each profile. Typical connection times at the surface are 5 to 10 minutes. Please note that these are approximate costs. Your actual costs will vary with provider and use.

B. The Float's Iridium Modem and Two-Way Communications

The float's Iridium modem (LBT) is a Model 9522A L-Band Transceiver made by Iridium Satellite, LLC. Peak RF power during transmission is 7 Watts. The LBT is mounted inside the float and is configured for use by Teledyne Webb Research during production. No user configuration or adjustment is required. Production testing includes full verification of float to host server communications. This is the reason for requiring activation of the SIM card 30 days in advance of shipment. Your reception capabilities must also be in place at that time (see "[Modem-to-Modem vs. RUDICS](#)").

When the float surfaces at the end of a profile the LBT is used to "register" with the Iridium system. This verifies that the float is able to see the sky. The float then disconnects from the Iridium system and uses the antenna to acquire a GPS fix. The fix is included in the data file returned to the host server (see "[Iridium Data](#)"). The LBT is then used to re-register with the Iridium system, upload hydrographic (10 - 20 Kbytes) and engineering (12 - 25 Kbytes) data files, and download any changes to the mission parameters (< 1 Kbyte).

The download file, mission.cfg, is stored on the host server and can be edited there when it is desirable to change the mission parameters. Each active line in the configuration file has the form:

ParameterName(argument) [CRC]

Inactive lines (comments) start with a '#' character. The CRC can be calculated using a Linux based utility, *chkconfig*, which is part of a software package developed at the University of Washington (see "[Modem-to-Modem vs. RUDICS](#)"). A mission.cfg template, which includes all of the mission parameters that interact with each other, is shown below:

```
AscentTimeout(Minutes)
DeepProfileDescentTime(Minutes)
DeepProfilePistonPos(Counts)
DeepProfilePressure(Decibars)
Downtime(Minutes)
ParkDescentTime(Minutes)
ParkPistonPos(Counts)
ParkPressure(Decibars)
PnPcycleLen()
Uptime(Minutes)
```

The *chkconfig* utility performs parameter sanity checks, so it is a good idea to include all of the commands above so that their safe interaction can be verified before the new configuration is downloaded by the float.

The mission.cfg file should not be empty, but it is sufficient to include only a comment or just a benign command such as `Verbosity(2)` if you do not wish to make any changes.

Other available configuration commands, which do not have interactive dependencies, are:

```
ActivateRecoveryMode()  
AirBladderMaxP(Counts)  
AtDialCmd()  
AltDialCmd()  
ConnectTimeout(Seconds)  
CpActivationP(Decibars)  
FlashErase()  
FlashCreate()  
FloatId()  
MaxLogKb(Kilobytes)  
Pwd()  
TelemetryRetry(Minutes)  
TimeOfDay(Minutes)  
UpTime(Minutes)  
User()  
Verbosity()
```

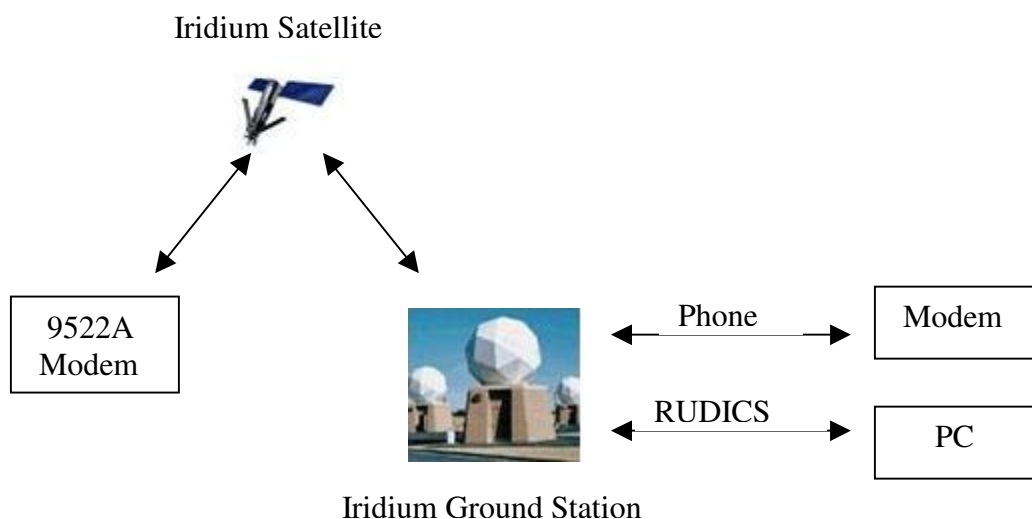
Several of these commands should only be used if absolutely required and then only with caution. For example, DO NOT change both the primary and the alternate dial commands at the same time.

Conversely, commands such as **CpActivationP(Decibars)** might be used frequently to adjust the range of high resolution sampling in response to observations of the water column returned by previous profiles.

C. Using Modem-to-Modem Communications

Iridium supports several different modes of operation for data communication, although APF9I firmware is currently only compatible with modem-to-modem communication (also referred to as *dial-up* service).

Modem-to-modem communication is illustrated in the following figure, which shows a float-installed 9522A Iridium modem communicating with the ground-station Iridium gateway, via an Iridium satellite. The Iridium gateway is then accessed for data by either phone-line (using a host server with a modem) or over the network (using the RUDICS service).



For modem-to-modem communications (without RUDICS) you will need independent primary and alternate host servers, each with a modem connected to the phone system to receive the calls and data from the float. A full description of this equipment and software is beyond the scope of this manual. However, Teledyne Webb Research makes regular use of U.S. Robotics external modems, Model USR3453C, Courier™ 56K Business Modem.

A Linux-based modem-to-modem solution has been developed by Dana Swift at the University of Washington. The software and documentation are available in a "tarball" at no charge; however, it requires some level of Linux expertise on your part to implement. If you are experienced with Linux the process is quite straightforward. You will need to acquire the servers, install and configure Linux, and reconcile any differences between the version of Linux on your host servers and the version of Linux under which the distribution was developed (RedHat Linux 9). The package automates the reception of data messages from multiple floats and fully supports two-way communication. Some user developed documentation of the implementation process is included later in this manual (see "[The Remote Unix Host](#)"). Additional Linux based packages for data processing are also available with limited support. Contact Teledyne Webb Research for further information.

An alternative to setting up the modem-to-modem solution yourself, especially if you are not comfortable with Linux or do not wish to set up and maintain host servers, is to contract out the reception of the calls and have the data provided to you by email, FTP, or web server. The contractor is then responsible for maintaining the servers and modems. This is similar to the long-standing ARGOS system. There are providers available and you may wish to investigate this possibility. Contact Teledyne Webb Research for additional information.

Another alternative to setting up the modem-to-modem solution yourself is to use RUDICS, the *Router-based Unrestricted Digital Internetworking Connectivity Solution*, which is available from several providers (including Iridium Satellite, LLC and NAL Research, Inc). RUDICS is Internet rather than phone based, which provides additional connection redundancy. The float makes calls as before and these are received at the Iridium ground-station. The data are then made available to you using a browser, through a website set up by your RUDICS provider. You do not need to maintain a host server and will only need a computer with broadband Internet access. RUDICS does have a large setup cost, but subsequent data costs and connection times are typically lower compared to other modem-to-modem solutions.

Although APF9I firmware is currently only compatible with modem-to-modem communication, several other Iridium communication modes exist. These include the *Short Burst Data* service (SBD) and the *Short Messaging Service* (SMS). SBD is a simple and efficient bi-directional transport capability used to transfer messages with sizes ranging from zero (a mailbox check) to 1960 bytes for Mobile Originated (MO-SBD) and zero to 1890 bytes for Mobile Terminated (MT-SBD) devices. SBD takes advantage of signals within the existing air interface, without using the dedicated traffic channels. As a result, small amounts of data can be transferred more efficiently than those associated with circuit-switched data calls. SBD messages can be delivered to the end-user using a variety of mechanisms including email and FTP. Alternatively, SMS transfers data messages up to 160 characters in length. SMS is a store-and-forward method of transmitting messages, geared towards mobile devices in which the message from the originator is stored in a central *Short Message Center* before being forwarded to its destination.

D. Bearer Service Type

The bearer service type (BST) specifies two characteristics of the phone call made from a modem at the Iridium ground station (where the signal from the satellite is received) to the modem on the host server where you are receiving the call and data from the float. These two characteristics of the call from the gateway modem to the server modem are:

- analog (tone) vs. digital (ISDN)
- serial baud rate

The default in many cases is digital. A problem can arise if your local phone company has only a limited number of ISDN lines available. The likely symptom during pre-deployment testing is a report from the float of "No carrier detected". This may occur either before or after a connection is established.

The solution is to force the conversation to be analog. This can be done by embedding a "CBST" command in the Primary and/or Alternate Dial Commands, Parameters Mhp and Mha. A standard dial command has the form:

ATDT0012223334444

ATDT is a command to the modem, 00 is the required calling prefix, and 12223334444 is the phone number of your modem, beginning with the country code. To embed the CBST command, alter the dial command as follows:

AT+CBST=71,0,1;DT0012223334444

The first argument of the CBST command, a '71' in the example above, specifies the baud rate according to the table below, which applies to modem version V.110. First argument values from the table (0, 66, 68, 70 and 71) also force the conversation to be analog. Your server modem should be set to match the commanded baud rate (or auto select). The second and third CBST arguments are always '0' and '1'.

CBST	Baud Rate
0,0,1	auto
66,0,1	1200
68,0,1	2400
70,0,1	4800
71,0,1	9600

E. Iridium Data

Iridium message files end with a ".msg" extension. Each iridium message file consists of blocks of similar data presented in the order that they were collected during the profile cycle. This firmware revision includes the following blocks of data:

- 1) Mission configuration for the current profile cycle. This is a listing of the values of each mission parameter.
- 2) Park-phase PTS samples: These are hourly PTS samples collected during the park phase of the profile cycle.
- 3) Rafos tracking data: These data are collected by the rafos receiver during the park-phase of the mission cycle and used to implement Rafos tracking.
- 4) Low resolution PTS samples: The deep parts of the profile can be represented using low-resolution spot samples collected at predetermined pressures. Low resolution spot sampling in the deep water was implemented as an energy savings measure.
- 5) High resolution PTS samples: The shallower parts of the profile can be represented with high resolution (ie., 2 decibar) bin-averaged PTS samples. In continuous profiling mode, the CTD samples at 1Hz and stores the data for later binning and averaging.
- 6) GPS fixes: After the profile is executed and the float reaches the surface, the location of the profile is determined via GPS.
- 7) Biographical & engineering data: Various kinds of biographical and engineering data are collected at various times during the profile cycle.

Usually, only one telemetry cycle is required to upload the data to the remote host computer. However, sometimes the iridium connection is broken or the quality of the connection is so poor that the float will abort the telemetry attempt, wait a few minutes, and then try again. Data blocks 4 and 5 will be repeated for each telemetry cycle of a given profile.

A description of the format for each of these blocks of data follows.

Mission configuration for the current profile cycle.

This is a listing of the values of each mission parameter as shown in the example below. Most of these parameters are subject to remote control and so their values may change from one profile cycle to the next. The current profile cycle was executed using these mission parameters.

```
$ Mission configuration for Apf9i(5233) FwRev 100909:
$ AscentTimeOut(540) [min]
$ AtDialCmd(ATDT59312) [primary]
$ AltDialCmd(ATDT63256) [alternate]
$ BuoyancyNudge(10) [count]
$ BuoyancyNudgeInitial(22) [count]
$ ConnectTimeOut(60) [sec]
$ CpActivationP(985) [dbar]
$ DeepProfileDescentTime(240) [min]
$ DeepProfilePistonPos(16) [count]
$ DeepProfilePressure(2000) [dbar]
$ DownTime(601) [min]
$ FloatId(5233)
$ FullExtension(227) [count]
$ FullRetraction(9) [count]
$ IceMLTCritical(-1.78)
$ IceMonths(0xFF)
$ MaxAirBladder(124) [count]
$ MaxLogKb(60) [KByte]
$ MissionPrelude(60) [min]
$ OkVacuum(110) [count]
$ PActivationPistonPosition(16) [count]
$ ParkDescentTime(240) [min]
$ ParkPistonPos(66) [count]
$ ParkPressure(1000) [dbar]
$ PnPCycleLen(1)
$ RafosWindowN(0)
$ TelemetryRetry(15) [min]
$ TimeOfDay(DISABLED) [min]
$ UpTime(660) [min]
$ Verbosity(2)
$ DebugBits(0x0002)
```

Park-Phase PT Sample format

Hourly PTS samples are collected during the park phase of the profile cycle. The park phase is also when active ballasting is done. Each sample includes the date & time of the sample, the unix epoch (ie., the number of seconds since 00:00:00 on Jan 1, 1970), the mission time (ie., the number of seconds since the start of the current profile cycle), the pressure (decibars), temperature (C), and the salinity (PSU). For example:

```
|----- date -----| UnixEpoch MTime P T S
ParkPts: Oct 09 2009 19:19:57 1255115997 14432 735.88 3.5873 34.855
```

Park-phase RAFOS tracking data

Up to six listening-windows worth of RAFOS tracking data will be generated as shown below. After the "Rafos:" key, the next three fields are the date & time, the Unix Epoch, and the mission time of the entry of the tracking data into the file. The next two fields are the Unix Epoch when the RAFOS receiver was activated followed by the span (seconds) of the RAFOS listening window. Next are six pairs of correlation-height & time-quantum-index. The correlation height has a range of 0x00-0xfa with higher values indicating higher correlations. The time-quantum index can be used to determine the time when the RAFOS signal was detected. The listening window is quantized into 0.3075s intervals and the time-quantum index indicates which interval is associated with the correlation height.

In the following RAFOS tracking data example, each line of data (starting with the Rafos: keyword) occupies two displayed lines on the page (due to limited page width). In each case, the second displayed line starts with the six pairs of correlation-height & time-quantum-index fields.

```
|----- date -----| UnixEpoch MTime |---- RAFOS ----|
|----- date -----| UnixEpoch MTime Activation Span
Rafos: Apr 21 2006 00:15:11 1145578511 38247 1145577602 900
C0 0503 34 003F 27 01B7 27 0054 26 032C 26 01CC
Rafos: Apr 21 2006 01:15:11 1145582111 41847 1145581202 900
B7 0501 32 06F9 2D 005D 2D 08E1 2D 09E0 2B 0933
Rafos: Apr 21 2006 02:15:11 1145585711 45447 1145584802 900
DB 0502 2B 0274 2B 003F 2A 08E5 28 00DC 27 0862
Rafos: Apr 21 2006 03:15:11 1145589311 49047 1145588402 900
B9 0500 39 0040 2B 01C2 29 0989 26 00DF 25 0951
Rafos: Apr 21 2006 04:15:11 1145592911 52647 1145592002 900
B6 0502 2E 0072 28 0040 28 0AD8 27 0187 27 0A43
Rafos: Apr 21 2006 05:15:11 1145596511 56247 1145595602 900
CB 0501 2D 06C6 27 0040 26 0AC0 25 064C 24 098F
```

Low Resolution PTS Sample format

The SBE41CP that is used on iridium floats has features that enable subsampling of the water column (similar to the SBE41) as well as the ability to bin-average a continuous sampling of the water column. For subsampled data, the values of pressure, temperature, and salinity are not encoded but are given in conventional units (decibars, C, PSU). For example:

\$ Discrete samples: 6

\$	p	t	s
1021.60	5.1719	34.6362	(Park Sample)
1994.88	2.4792	34.7165	
1947.50	2.5454	34.7142	
1898.08	2.6260	34.7115	
1847.83	2.7133	34.7076	
1797.26	2.8271	34.7017	
1746.87	2.8982	34.6964	

High Resolution PTS Sample format

For continuously sampled data, 2-decibar bins are used for bin-averaging. These data are encoded as three 16-bit integers (PTS) and then an 8-bit integer that represents the number of samples in the bin:

```
# Sep 26 2006 14:33:18 Sbe41cpSerNo[1520] NSample[11469] NBin[495]
0000000000000000[2]
002B5DD0876A11
003C5DD0876A18
00505DD2876A16
00645DD2876A14
00785DD2876A15
008C5DD5876916
00A05DD287691A
00B45DD4876920
00C85DD587692F
00DC5DD4876930
00F05DD3876933
01045DD487692A
01185DD2876B21
012C5DC7877125
01405DB8877524
01545D7B878220
01685D2887A51D
[snippage...]
```

The first 4-bytes of the encoded sample represents the pressure in centibars. The second 4-bytes represents the temperature in millidegrees. The third 4-bytes represent the salinity in parts per million. The final 2-bytes represent the number of samples collected in the 2dbar pressure bin.

For example, the encoding: 26980EDE86A011 represents a bin with (0x11=) 17 samples where the mean pressure was (0x2698=) 988.0dbars, the mean temperature was (0x0EDE=) 3.806C, and the mean salinity was (0x86A0=) 34.464PSU. The PTS values were encoded as 16-bit hex integers according to the functions below.

Integers in square brackets '['] indicate replicates of the same encoded line. For example, a line that looks like: 0000000000000000[2] indicates that there were 2 adjacent lines with the same encoding....all zeros in this case.

Conversion Notes:

The pressure range is -3276.7 dbar to 3276.7 dbar. Hex values 0x7FFF, 0x8000, 0x8001, and 0xFFFF are used to flag out-of-range (and edge-of-range) measurements or are otherwise reserved. Pressures in the range -0.15 dbar to -0.05 dbar are mapped to 0xFFFE → -0.2 dbar.

The temperature range is -4.095 °C to 61.439 °C. Hex values 0xF000, 0xF001, 0xEFFF, and 0xFFFF are used to flag out-of-range (and edge-of-range) measurements or are otherwise reserved. Temperatures in the range -0.0015 °C to -0.0005 °C are mapped to 0xFFFE → -0.002 °C.

The salinity range is -4.095 psu to 61.439 psu. Hex values 0xF000, 0xF001, 0xEFFF, and 0xFFFF are used to flag out-of-range (and edge-of-range) measurements or are otherwise reserved. Salinities in the range -0.0015 psu to -0.0005 psu are mapped to 0xFFFE → 65.534 psu.

To convert the hex values in an Iridium message file to physical units, proceed as described in the table below. The initial conversion from Hexadecimal to Decimal should assume the hex value is an unsigned integer with a range of 0 to 65535.

Measurement	Hexadecimal [Decimal comparison]	Decimal and Conversion Steps	Physical Result
Pressure ≥ 0	0x1D4C (≤ 0x7FFF) → [7500 (≤ 32767)]	P = 7500 P / 10 →	750.0 dbar
Pressure < 0	0xFFFA (≥ 0x8001) → [65530 (≥ 32769)]	P = 65530 (P - 65536) / 10 →	-0.6 dbar
Temperature ≥ 0	0x3EA6 (≤ 0xEFFF) → [16038 (≤ 61439)]	T = 16038 T / 1000 →	16.038 °C
Temperature < 0	0xF58B (≥ 0xF001) → [62859 (61441)]	T = 62859 (T - 65536) / 1000 →	-2.677 °C
Salinity ≥ 0	0x8FDD (≤ 0xEFFF) → [36829 (≤ 61439)]	S = 36829 S / 1000 →	36.829 psu
Salinity < 0	0xFF9C (≥ 0xF001) → [65436 (≥ 61441)]	S = 65436 (S - 65536) / 1000 →	-0.100 psu

GPS Fixes

Before each telemetry cycle the float attempts to acquire a GPS fix. An example of a successful fix, as reported in an Iridium message file, is shown below. The information includes the latitude and longitude of the float, time required to obtain the location, the date and time the information was acquired, and the number of satellites used. Longitude is positive in the eastern hemisphere and negative in the western hemisphere. Latitude is positive in the northern hemisphere and negative in the southern hemisphere. Date and time are presented in the format shown in the example.

```
# GPS fix obtained in 98 seconds.  
#      lon      lat mm/dd/yyyy hhmmss nsat  
Fix: -152.945  22.544 09/01/2005 104710    8
```

If the float is not able to obtain a GPS fix this block of the message file will instead contain the message below:

```
# Attempt to get GPS fix failed after 600 seconds.
```

Biographical and Engineering Data

The biographical and engineering data occupy the last block in the Iridium message file. These data have the form "key"="value". An example is shown below.

```
ActiveBallastAdjustments=5  
AirBladderPressure=119  
AirPumpAmps=91  
AirPumpVolts=192  
BuoyancyPumpOnTime=1539
```

Interpretation of this information requires detailed knowledge of the firmware. A full description is beyond the scope of this manual. Contact Teledyne Webb Research for assistance. General conversions for voltage, current and vacuum are provide below.

Volts	V	8 bits unsigned	$V = (V_{\text{raw}} * 0.077 + 0.486$
Current	MA	8 bits unsigned	$I = (I_{\text{raw}} * 4.052) - 3.606$
Vacuum	InHg	8 bits unsigned	$V = (V_{\text{raw}} * 0.293) - 29.767$

F. Pressure Table for PTS Samples

The Pressure Table, below with values expressed in decibars (dbar), defines where discrete PTS measurements are acquired during a profile. The change to continuous profiling is controlled by Parameter Mc, Continuous profile activation pressure (decibars). Discrete PTS samples are taken according to the Pressure Table when the measured pressure is greater than the activation pressure. PTS sampling is continuous (1 Hz) with 2 dbar bin averages reported when the measured pressure is less than the activation pressure.

Depth Table 30, below, with values expressed in decibars (dbar), defines where PTS measurements are acquired during a profile.

700	580	460	375	315	255	195	135	75	15
690	570	450	370	310	250	190	130	70	10
680	560	440	365	305	245	185	125	65	5
670	550	430	360	300	240	180	120	60	4 or
660	540	420	355	295	235	175	115	55	Surface
650	530	410	350	290	230	170	110	50	
640	520	405	345	285	225	165	105	45	
630	510	400	340	280	220	160	100	40	
620	500	395	335	275	215	155	95	35	
610	490	390	330	270	210	150	90	30	
600	480	385	325	265	205	145	85	25	
590	470	380	320	260	200	140	80	20	

To prevent fouling of the CTD by surface and near-surface contaminants, the APF9I halts continuous profiling 4 dbar deeper than the most recent surface pressure measurement.

G. The Remote UNIX Host

This iridium implementation uses a modem-to-modem communications model. The float initiates a telephone call to a remote host computer, logs into the remote host with a username and password, executes a sequence of commands to transfer data, and then logs out. The communications session is float-driven

With respect to the remote host, there is no difference between the float logging in and a human logging in. The communications session is initiated and fully controlled by the float. On the other hand, the float is not naturally adaptable or interactive like a human would be and so an unusual amount of fault tolerance has been built into both sides of the communications session.

An important fault tolerance measure is redundancy in the form of two similarly configured remote hosts each with its own dedicated telephone line. This is optional but recommended. Ideally, these two remote hosts should be separated far enough from each other that power outages or telephone outages are not likely to simultaneously affect both remote hosts. The float firmware is designed to automatically switch to the alternate remote host if with the primary remote host appears to be out of service.

System Requirements

This iridium implementation is strongly tied to the use of a UNIX computer as the remote host (ie., Microsoft operating systems are not suitable). The most important "system requirement" is a system administrator that is familiar, comfortable, and competent in a UNIX environment. While many different flavors of UNIX could be made to work, development was done using RedHat Linux (versions 7-9). RedHat Linux (version 9) will be assumed for the remainder of this section.

The **mgetty** package must be installed and configured to monitor a Hayes-compatible external modem attached to one of the serial ports. For information on how to install and configure the **mgetty** package, refer to the **mgetty** documentation supplied with RedHat Linux. If you customize the login prompt, make sure that it includes the phrase "login:". Similarly, make sure that the password prompt includes the phrase "Password:". The float will not successfully log in if these two phrases are not present.

Once **mgetty** is installed and configured properly, you should be able to log into the remote host via a modem-to-modem connection from another computer. You should test this using the following communications parameters: 4800baud, no parity, 8-bit data, 1 stop-bit.

Remote Host Set Up

Once each telemetry cycle, the float downloads "mission.cfg" from the home directory where the float logs in and this new mission configuration becomes active as the last step before the

telemetry cycle terminates. In the context of a UNIX environment, this simple mechanism allows for great flexibility for remotely controlling floats individually, in groups, or fleet-wise. It is also flexible in that it is possible to switch which model is used even after floats have been deployed. Finally, a UNIX-based remote host facilitates easy speciation of floats as well as for new float developments with no requirement for backward compatibility.

Setting up the Default User on the Remote Host

Another fault tolerance measure requires creation of a *default user* on the remote host. Begin by creating a new *iridium* group to which the *default user* and all floats will belong. As root, execute the command:

```
groupadd -g1000 iridium
```

Next, create an account for the *default user* using *iridium* as the username:

```
adduser -s/bin/tcsh -c "Iridium~Apex~Drifter" -g "iridium"  
-u1000 -d/home/iridium iridium
```

Then give the new user a password by executing (as root):

```
passwd iridium
```

For the convenience of the float manager, you might also want to change the permissions on the float's home directory:

```
chmod 750 ~iridium
```

The file, */etc/passwd*, will contain the following entry:

```
iridium:x:1000:1000:Iridium Apex Drifter:/home/iridium:/bin/tcsh
```

The remainder of the set-up for this float should be done while logged into the remote host as the default user (ie., *iridium*). Create two directories:

```
mkdir -/bin -/logs
```

and populate the *-/bin* directory with the *SwiftWare* xmodem utilities **rx** and **sx** as well as the **chkconfig** utility. These three files are in the **support** directory of your distribution.

Finally, use **emacs** to create the following three ascii files: **.cshrc**, **.rxrc**, and **.sxrc**:

.cshrc: This file configures the t-shell at login time. You can modify the configuration to suit yourself so long as your customizations do not interfere with the effects that the three commands below have. In particular, it is important that the float's **bin** directory be in the *path* before any

of the system directories. This will ensure that the float's version of the utilities **chkconfig**, **rx**, and **sx** will be used rather than the system's utilities with these same names.

```
# set the hostname
set hostname=`hostname`

# add directories for local commands
set path = (. ~/bin /bin /sbin /usr/sbin /usr/local/bin)

# set the prompt
set prompt=" "$hostname":[$cwd]> "
```

.rxrc: This is the configuration file for the *SwiftWare* implementation the xmodem receive utility. *SwiftWare* implements the standard xmodem protocol except that a nonstandard 16-bit CRC is used. Beware that the float will not be able to transfer any hydrographic or engineering data to the remote host using the system version of **rx**. Make sure that the *LogPath* references the *default user's logs* directory or else potentially valuable logging/debugging information will be irretrievably lost.

```
# This is the configuration file for 'rx', the
# SwiftWare xmodem receive utility.

# set the default debug level (range: 0-4)
Verbosity=5

# specify the name of the log file
LogPath=/home/iridium/logs/rxlog

# enable (AutoLog!=0) or disable (AutoLog==0)
# the auto-log feature
AutoLog=1

# specify ascii mode (BinaryMode==0) or
# binary mode (BinaryMode!=0)
BinaryMode=0

# specify CRC mode (16bit or 8bit)
CrcMode=16bit
```

.sxrc: This is the configuration file for the *SwiftWare* implementation the xmodem send utility. *SwiftWare* **sx** implements the standard xmodem protocol except that a nonstandard 16-bit CRC is used. Beware that new mission configurations will not be downloaded from the remote host to the float if system version of **sx** is used. Make sure that the *LogPath* references the *default user's logs* directory or else potentially valuable logging/debugging information will be irretrievably lost.

```
# This is the configuration file for 'sx', the
# SwiftWare xmodem send utility.
```

```
# set the default debug level (range: 0-4)
Verbosity=5

# specify the name of the log file
LogPath=/home/iridium/logs/sxlog

# enable (AutoLog!=0) or disable (AutoLog==0)
# the auto-log feature
AutoLog=1

# specify fixed packet type (128b or 1k)
# PktType=1k
```

Setting up the Remote Host for Individualized Remote Control

The ability to individualize each float is implemented by each float having its own account on the remote host. The steps to set up the remote host are analagous to those for setting up the *default user*. For example, to create an account for float 5047 make sure the **iridium** group exists and then execute the following command (as root):

```
adduser -s/bin/tcsh -c "Iridium~Apex~Drifter" -g "iridium" -u15047 -d/home/f5047 f5047
```

Then give the new user a password and change the permissions of the float's home directory as shown for the *default user*. **Be sure to configure the float to use this username and password.** The file, /etc/passwd, will contain the following entry:

```
f5047:x:15047:1000:Iridium Apex Drifter:/home/f5047:/bin/tcsh
```

The remainder of the set-up for this float follows very closely that of the *default user* and should be done while logged into the remote host as the float (ie., *f5047*). Create **bin** and **logs** directories in the float's home directory and populate the **bin** directory with the *SwiftWare* xmodem utilities **rx** and **sx** as well as the **chkconfig** utility.

Finally, copy the three ascii files **.cshrc**, **.rxrc**, and **.sxrc** from the *default user's* home directory to the float's home directory. Be sure to edit these files so that the *LogPath* points to the float's **logs** directory or else potentially valuable logging/debugging information will be irretrievably lost.

Setting up the Remote Host for Fleet-Wise Remote Control

The flexibility inherent with individualized float control necessarily increases the level of operational management required - each float has to be considered and controlled individually. However, fleet-wise management of floats is also made possible by configuring the float to use a fleet-wise username. This is in contrast to configuring each float with a unique username (based

on the float serial number). The steps to set up the remote host for fleet-wise control are virtually the same as those for setting up the remote host for a default user, except that the username and password are fleet-wise parameters. Be sure to configure each float in the fleet with the fleet-wise username and password.

Iridium Serial Number Handling

The SIM phone book is programmed with the phone number assigned to the SIM (MSISDN) Mobile System Integrated Services Digital Network and the SIM ID number (ICCID) Integrated Circuit Card Identification. The firmware will be able to query the LBT because it cannot be done through the standard AT commands. This protects against SIM cards being swapped between floats. If a float fails after deployment, there is a record of which SIM card is coupled to a particular float that allows the SIM card to be deactivated.

This information can be programmed using a terminal emulation program (19200 N-8-1), LBT test fixture and the following commands:

1. AT (wait 60 seconds)
2. AT+CPBS="SM"
3. AT+CPBW=101, "<CCID>", 129, "<MSISDN>"
4. AT+CPBS?
5. AT+CPBR=101 (to verify)

where <CCID> and <MSISDN> are actual values.

Note: If the PIN needs to be set, use the following command: AT+CPIN="<PIN>" .

GPS, LBT, Remote Host Testing

After connecting to an iridium antenna, enter sail commands via a terminal emulation program (9600 8-N-1). Press any key to enter command mode ">" prompt.

```
gc (configure the GPS)
gp (access satellites and set the real time clock)
gf (get a GPS fix)
hc (configure the Iridium modem)
r (activate recovery mode where a GPS fix is followed by an
Iridium call and once a connection established, upload
mission.cfg and download log information to the remote host.)
k (when complete, kill mission by responding with a "y")
```

Appendix A: Storage conditions

For optimum battery life, floats should be stored in a controlled environment in which the temperature is restricted to the range +10 °C to +25 °C. When activated, the floats should be equilibrated at a temperature between -2 °C and +54 °C before proceeding with a deployment.

If the optional VOS or aircraft deployment containers are used, they must be kept dry, and should only be stored indoors.

Appendix B: Connecting a Terminal

The float can be programmed and tested by an operator using a 20 mA current loop and a terminal program. The current loop has no polarity. Connections should be made through the hull ground and a connector or fitting that is electrically isolated from the hull. This is shown in the image below. In this case one side of the current loop is clipped to the zinc anode and the other is clipped to the pressure port.

The communications cables and clamps are included in the float shipment. An RS-232 to current-loop converter is provided with the communications cables. This converter requires a 12 VDC supply.

The RS-232 communications cable should be connected to the COM port of a PC. Run a communications program such as ProComm or HyperTerminal on the PC. Both programs can be downloaded from various Internet sites.

HyperTerminal is generally included with distributions of the Windows Operating System.



COM Port Settings: 9600, 8, N, 1

- 9600 baud
- 8 data bits
- No parity
- 1 stop bit
- no flow control / no handshaking
- full duplex

Teledyne Webb Research recommends the practice of capturing and archiving a log file of all communications with each float. If in doubt about a test, email the log file to your chief scientist and/or to Teledyne Webb Research.

Once you have started the communications program and completed the connections described above, press [ENTER] to wake the float from Hibernate mode. The float will respond that it has detected an "asynchronous wake-up" and will enter Command mode. Press [ENTER] in Command mode to display the main menu. Menu selections are not case sensitive. See "[APF9I Command Summary](#)" for a complete list of available commands.

Appendix C: APF9I Command Summary

Uppercase commands are used here for clarity; however, APF9I commands are not case sensitive. The menus presented below were copied verbatim from a terminal session with an APF9I controller. ">" is the APF9I prompt for operator input. The first menu is displayed in response to either a question mark ("?",) or the [ENTER] when no preceding command is entered.

IMPORTANT: Piston full extension, set with menu parameter Ff, is calibrated and set at the factory. Do not alter the value of Ff shown in the “Missions” appendix. Using a value larger than the factory setting may result in severe damage to the pump.

Main Menu (Command Mode)

```
> ?
Menu selections are not case sensitive.
? Print this help menu.
A Initiate pressure-activation of mission.
C Calibrate: battery volts, current, & vacuum.
D Set logging verbosity. [0-5]
E Execute (activate) mission.
G GPS module agent.
G? GPS module menu.
H LBT module agent.
H? LBT module menu.
I Diagnostics agent.
I? Diagnostics menu.
J FLASH file system agent.
J? FLASH file system menu.
K Kill (deactivate) mission.
L List mission parameters.
M Mission programming agent.
M? Mission programming menu.
N Display float serial number.
P Display the pressure table.
Q Exit command mode.
R Activate recovery mode.
S Sensor module agent.
S? Sensor module menu.
T Get/Set RTC time. (format 'mm/dd/yyyy:hh:mm:ss')
U Attach the logstream to a specified file.
V Close the log file.
```

The sub-menus shown below, GPS (G?), LBT (H?), File System (J?), CTD (S?), and System Diagnostics (I?), are all accessible from the Main Menu (Command Mode) using the appropriate letter and question mark combination. The float remains in command mode when displaying these sub-menus, so the Main Menu commands remain active. Entering the Mission programming agent (M), however, exits from command mode until you quit (Q) the Mission

Programming Agent. List Mission Parameters (L) is an active command in both Command Mode and the Mission Programming Agent.

Command Mode Sub-Menus

GPS Menu

> G ?
Menu of Garmin GPS15L-W functions.
? Print this menu.
Ga Upload almanac to GPS15L-W.
Gc Configure the GPS15L-W.
Gf Get GPS15L-W fix.
Gl Log NMEA sentences from GPS15L-W.
Gt Synchronize the Apf9 clock with GPS.

LBT Menu (Iridium Modem)

> H ?
Menu of modem functions.
? Print this menu.
Hc Configure the modem.
Hf Query modem's firmware revision.
Hi Query modem's IMEI number.
Hm Query modem's model.
Hr Register the LBT with the Iridium system.
Hs Query SIM card's ICCID & MSISDN numbers.

FLASH File System Menu

> J ?
Menu of FLASH file system functions.
? Print this menu.
Jb Print bad-block list.
Jc Create FLASH file system (destructive).
Jd Print the FLASH chip identifier.
Je Erase the FLASH file system (destructive).
Jl Print directory listing of FLASH file system.
Jr Report FLASH errors since file system creation.
Jz Reset FLASH error counters to zero.

Ice Evasion Control Menu

Menu of ice evasion control parameters.
? Print this menu.
Ib Winter-months bitmask (DNOSAJJMAMFJ). [0x000,0xffff]
Id Display ice avoidance parameters.
It Under-ice mixed-layer critical temperature [-3,35]. (C)

Command Mode Sub-Menus (continued)

Sensor Menu (Seabird SBE-41cp)

> S ?
Menu of SBE41cp functions.
? Print this menu.
Sa Activate CP mode.
Sb Bin-average CP data.
Sc Display the SBE41cp calibration coefficients.
Sd Deactivate CP mode.
Sf Display SBE41cp firmware revision.
Sk Configure the SBE41cp.
Sm Measure power consumption by SBE41cp.
Sn Display SBE41cp serial number.
Sp Get SBE41cp pressure.
Ss Get SBE41cp P T & S.
St Get SBE41cp P & T (low-power).
Su Upload CP data.

System Diagnostics Menu

> I ?
Menu of diagnostics.
? Print this menu.
a Run air pump for 6 seconds.
b Move piston to the piston storage position.
c Close air valve.
d Display piston position
e Extend the piston 4 counts.
g Goto a specified position. [1-254] (counts)
l Set maximum engineering log size. [5-63] (KB)
o Open air valve.
r Retract the piston 4 counts.
s Execute the SelfTest().
t Calculate ToD down-time expiration.
1 Run air pump for 6 seconds (deprecated).
5 Retract the piston 4 counts (deprecated).
6 Extend the piston 4 counts (deprecated).
7 Display piston position (deprecated).
8 Open air valve (deprecated).
9 Close air valve (deprecated).

Mission Programming Agent

The interaction recorded below shows the operator entering the Mission Programming Agent from Command Mode (M), displaying the available commands (?), and quitting the agent (Q) to return to Command Mode. Note that the system performs sanity checks on the mission parameters when leaving the Mission Programming Agent. Warnings will be displayed if problems are detected.

```
> M Entering Mission Programming Agent
> ?
Menu selections are not case sensitive.
? Print this menu.
A Self-activation pressure. [25-1500] (dbars)
B Buoyancy control agent.
Bi Ascent initiation buoyancy nudge. [25-254] (counts)
Bj Deep-profile piston position. [1-254] (counts)
Bn Ascent maintenance buoyancy nudge. [5-254] (counts)
Bp Park piston position [1-254] (counts)
C Continuous profile activation pressure (decibars).
F Float vitals agent.
Fb Maximum air-bladder pressure. [1-254] (counts)
Ff Piston full extension. [1-254] (counts)
Fs Storage piston position. [1-254] (counts)
Fv OK vacuum threshold. [1-254] (counts)
H Host configuration agent.
Ha Dial command for alternate host.
Hp Dial command for primary host.
Hr Telemetry retry interval. [1-60 minutes]. (← typographical error
Ht Host-connect time-out. [30-300 seconds]. in the firmware,
I Ice avoidance agent.
Ib winter-months bitmask (DNOSAJJMAMFJ). [0x000,0xffff]
Id Display ice avoidance parameters.
It Under-ice mixed-layer critical temperature [-3,35]. (C)
J Deep-profile pressure. (0-2000] (decibars) range is [1-360])
K Park pressure. (0-2000] (decibars)
L List mission parameters.
N Park and profile cycle length. [1-254]
Q Quit the mission programming agent.
T Mission timing agent.
Ta Ascent time-out period. [120-600] (Minutes)
Tc Time-of-day for expiration of down-time [0-1439] (Minutes).
Td Down time (0-336 hours] (Minutes).
Tj Deep-profile descent time. [0-480] (Minutes).
Tk Park descent time. (0-480] (Minutes).
Tp Mission prelude. (0-360] (Minutes).
Tr Telemetry retry interval. [1-360] (Minutes).
Tu Up time (0-1440] (Minutes).
Z Analyze the current mission programming.
> Q
All constraints and sanity checks passed.
Quitting Mission Programming Agent.
>
```


Listing Mission Parameters

```
> L
APEX version 101109  sn ...
User: ...
Pwd: ..
Pri: ATDT...
Rafos: 60;60 (Minutes)
Alt: ATDT..
INACTV ToD for down-time expiration. (Minutes)
13970 Down time. (Minutes)
00430 Up time. (Minutes)
00340 Ascent time-out. (Minutes)
00360 Deep-profile descent time. (Minutes)
00360 Park descent time. (Minutes)
00360 Mission prelude. (Minutes)
00015 Telemetry retry interval. (Minutes)
00060 Host-connect time-out. (Seconds)
1200 Continuous profile activation. (Decibars)
1200 Park pressure. (Decibars)
1200 Deep-profile pressure. (Decibars)
016 Park piston position. (Counts)
016 Deep-profile piston position. (Counts)
010 Ascent buoyancy nudge. (Counts)
022 Initial buoyancy nudge. (Counts)
254 Park-n-profile cycle length.
-1.80 Ice detection: Mixed-layer Tcritical (C)
0xffd Ice detection: Winter months [DNOSAJJMAMFJ]
124 Maximum air bladder pressure. (Counts)
096 OK vacuum threshold. (Counts)
227 Piston full extension. (Counts)
016 P-Activation piston position
2 Logging verbosity. [0-5]
ce40 DebugBits.
```

Mhp
Mtw
Mha
Mtc
Mtd
Mtu
Mta
Mtd
Mtk
Mtp
Mhr
Mht
Mc
Mk
Mj
Mbp
Mbj
Mbn
Mbi
Mn
Mit
Mib
Mfb
Mfv
Mff
Mfs
D
D

Note that Mission Parameters are changed by entering the Mission Programming Agent (M) from the Main Menu (Command Mode).

Appendix D: Returning APEX floats for factory repair or refurbishment

Contact Teledyne Webb Research before returning APEX floats for repair or refurbishment. All returns from outside USA, please specify our import broker:

Consignee: Teledyne Webb Research
82 Technology Park Drive
East Falmouth, MA 02536

Notify: DHL-Danzas Freight Forwarding Agents
Attn: Ellis Hall, Import Broker
Phone (617) 886-6665, FAX (617) 242-1470
500 Rutherford Avenue
Charlestown, MA 02129

Note on shipping documents: US MADE GOODS

CAUTION: If the float was recovered from the ocean, it may contain water, which presents a safety hazard due to possible chemical reaction of batteries in water. The reaction may generate explosive gases (see "Alkaline Battery Warning" at the beginning of this manual). In this case, be sure to remove the seal plug to ventilate the instrument before shipping. Do this in a well ventilated location and do not lean over the seal plug while loosening it. Use a 3/16 inch hex wrench, or pliers, to rotate the plug counter-clockwise.



Appendix E: Missions

This section lists the parameters for each float covered by this manual.

To display the parameter list, connect a communications cable to the float, press <ENTER> to wake the float from hibernate and start command mode, and press 'I' or 'L' to list the parameters. See "[Connecting a Terminal](#)" and "[APF9I Command Summary](#)" for more information.

INSTRUMENT # 5396

APEX version 120210 sn 7087

User: f7087

Pwd: 0xf744

Pri: AT+CBST=71,0,1;ATDT00881600005133 Mhp

Alt: ATDT0015085480980 Mha

Rafos: 0; (Minutes) Mtw

INACTV ToD for down-time expiration. (Minutes) Mtc

00810 Down time. (Minutes) Mtd

00630 Up time. (Minutes) Mtu

00180 Ascent time-out. (Minutes) Mta

00030 Deep-profile descent time. (Minutes) Mtj

00030 Park descent time. (Minutes) Mtk

00360 Mission prelude. (Minutes) Mtp

00015 Telemetry retry interval. (Minutes) Mhr

00060 Host-connect time-out. (Seconds) Mht

100 Continuous profile activation. (Decibars) Mc

100 Park pressure. (Decibars) Mk

100 Deep-profile pressure. (Decibars) Mj

066 Park piston position. (Counts) Mbp

066 Deep-profile piston position. (Counts) Mbj

010 Ascent buoyancy nudge. (Counts) Mbn

022 Initial buoyancy nudge. (Counts) Mbi

254 Park-n-profile cycle length. Mn

-1.80 Ice detection: Mixed-layer Tcritical (C) Mit

0xffd Ice detection: Winter months [DNOSAJJMAMFJ] Mib

124 Maximum air bladder pressure. (Counts) Mfb

096 OK vacuum threshold. (Counts) Mfv

226 Piston full extension. (Counts) Mff

016 P-Activation piston position. (Counts) Mfs

2 Logging verbosity. [0-5] D

0002 DebugBits. D

f602 Mission signature (hex).

INSTRUMENT # 5397

APEX version 120210 sn 7126

User: f7126

Pwd: 0x3f9e

Pri: AT+CBST=71,0,1;ATDT00881600005133 Mhp

Alt: ATDT0015085480980 Mha

Rafos: 0; (Minutes) Mtw

INACTV ToD for down-time expiration. (Minutes) Mtc

00810 Down time. (Minutes) Mtd

00630 Up time. (Minutes) Mtu

00180 Ascent time-out. (Minutes) Mta

00030 Deep-profile descent time. (Minutes) Mtj

00030 Park descent time. (Minutes) Mtk

00360 Mission prelude. (Minutes) Mtp

00015 Telemetry retry interval. (Minutes) Mhr

00060 Host-connect time-out. (Seconds) Mht

100 Continuous profile activation. (Decibars) Mc

100 Park pressure. (Decibars) Mk

100 Deep-profile pressure. (Decibars) Mj

066 Park piston position. (Counts) Mbp

066 Deep-profile piston position. (Counts) Mbj

010 Ascent buoyancy nudge. (Counts) Mbn

022 Initial buoyancy nudge. (Counts) Mbi

254 Park-n-profile cycle length. Mn

-1.80 Ice detection: Mixed-layer Tcritical (C) Mit

0xffd Ice detection: Winter months [DNOSAJJMAMFJ] Mib

124 Maximum air bladder pressure. (Counts) Mfb

096 OK vacuum threshold. (Counts) Mfv

226 Piston full extension. (Counts) Mff

016 P-Activation piston position. (Counts) Mfs

2 Logging verbosity. [0-5] D

0002 DebugBits. D

ef05 Mission signature (hex).